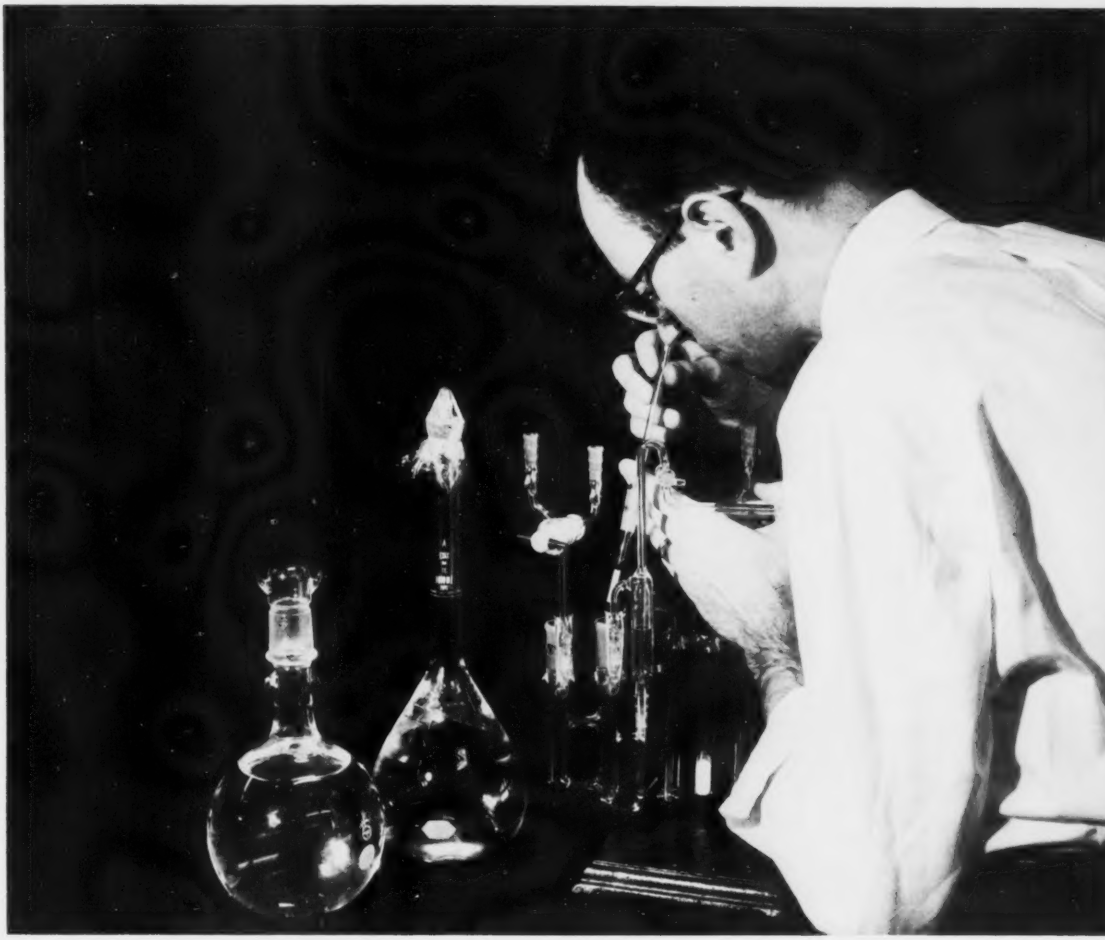
NATIONAL BUREAU OF STANDARDS June / 1965

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

U.S. DEPARTMENT OF COMMERCE
John T. Connor, Secretary
NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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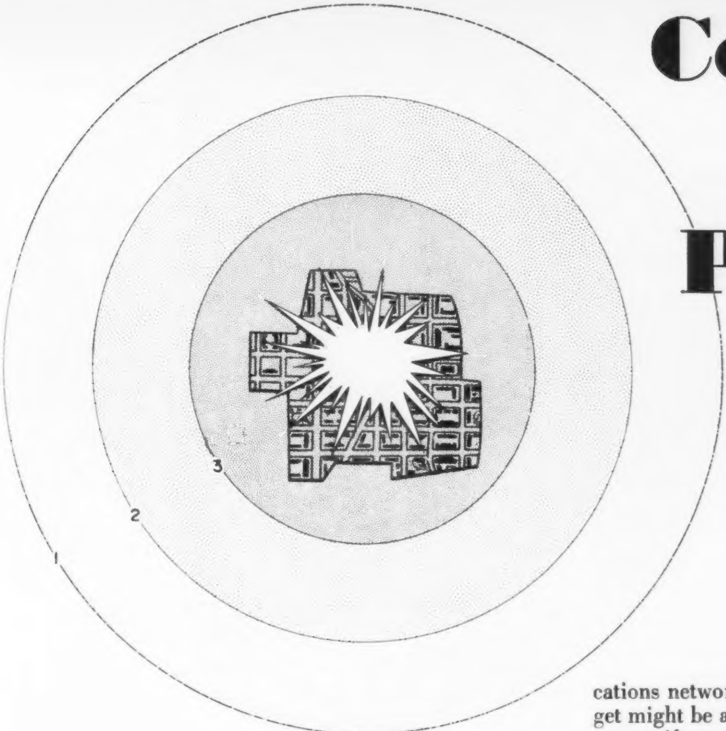
COVER: Robert Gary, NBS chemist, inserts a platinum electrode into a cell used to measure the emf of heavy water buffer solutions. Such measurements were used to calculate reference points on the newly established pD scale. (See p. 87)

Computer Plots Potential Nuclear Damage



Study by Mai Liis Joel and
Douglas D. Lottridge,
NBS Institute for Applied Technology

A COMPUTER program [1] developed at the Bureau will aid the Defense Communication Agency in planning installations of its worldwide communications network. The DCA is designing the system for continued operation in the event of any national emergency; its sites, materials, and construction features must therefore be selected to withstand the effects of a nuclear bomb.

The computer program can be used to determine the lethal radii of overpressures around prime targets. The results of the computation are encoded on magnetic tape, which drives a plotter to produce overlays. These overlays, when superimposed on standard maps, show the "hardness" required of installations to withstand hypothetical nuclear attacks.

Overpressure From Nuclear Blasts

A nuclear detonation affects life, structures, and weather in several ways—by the shock wave, heat, and other radiation. The DCA is interested in knowing the immediate effects of hypothetical detonations of assumed intensity and height on stations of a communications network. Stations directly under a prime target might be annihilated, some a few miles away might escape if massively protected, and others still farther out might survive even though poorly protected. To plan its communications system, the DCA must know, for certain assumed attacks, just how much protection would be needed at alternative locations.

A nuclear detonation produces concentric shock waves, like those in this representation of a map seen through an overlay, on which circles of overpressure have been plotted. Numbers identify overpressure at radii.

The immediate destructive power of an explosion can be calculated as "overpressure" (shock wave pressure in pounds per square inch above the prevailing atmosphere) if the distance from the burst and its height and yield are known. The overpressure from a given blast becomes less with increasing distance from it. In this program, the overpressure is assumed to be the same at all points equidistant from the blast; thus circles of overpressure values can be drawn around a target.

Facility Hardness

The ability of a structure to withstand a blast, called "hardness," is expressed as the pounds of overpressure which it can withstand. A building hardened to 2 psi could withstand blasts having overpressures less than 2 psi but would be destroyed by greater ones. The hardness requirements of a more remote site might be lower and cost of construction there less, but this advantage would have to be balanced against any increased cost and uncertainty of maintaining and communicating with the station. Geographic presentations of hardness requirements are essential to the DCA, since site selection may involve trade-offs among several factors.

The DCA can now quickly determine lethal radii of overpressures around prime targets by use of the Bu-

Mai Liis Joel holds map on which a transparent overlay, here being removed from the plotter by Douglas Lottridge, will be positioned.

reau program to compute and plot the circles along which specified values of overpressure are expected. This computation is performed on a digital computer and the results encoded on magnetic tape. The tape is used to drive a plotter printing concentric circles of overpressures on transparent overlays of the same scale as the World Aeronautical Charts. The hardness requirements at tentative sites for specific hypothesized attacks of one or several simultaneous blasts can be visually determined and compared by placing the appropriate overlay on the chart showing the assumed target and sites being considered.

The computer program and the overlays produced admittedly do not take into consideration all factors which affect the suitability of facility sites. Considerations of topography and prevailing climate could be added to an overlay, but would seriously limit ease of using the method. In its present form, the program provides readily available guidelines, as required, eliminating the need for laborious hand calculations and manual mapping.

Correction for Off-Target Blasts

The fact that a bomb may not detonate immediately above its intended target, but may miss in an unpredictable direction by a distance related to probability, is allowed for in the computer program by the "circular error probable" (CEP) factor. A miss would result in overpressures higher than calculated at one side of the target and the destruction of facilities not adequately overhardened, while facilities on the opposite side of the target would be less taxed and their survival more favored. The program makes allowance for the CEP in order to evaluate realistically the worst-case overpressure.

The probabilities of overpressure exceeding hardness for various CEP distance values have been calculated. These can be used to select a specified number of CEP's to be added to each lethal radius; this "CEP multiplier" is an input parameter of the program. Its net effect is to enable some facilities to meet off-target excesses and to give others the advantage of being overhardened.

[1] *For details see* A program for plotting circles of constant overpressure around targeted points, *by Mai Liis Joel and Douglas D. Lottridge, NBS Tech. Note 249 (Oct. 1964), available for 40 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.*

NBS establishes pD scale

SINCE WORLD War II, the use of heavy water has increased in both science and industry. For instance, heavy water (deuterium oxide, D_2O) is used as a moderator and coolant in atomic reactors and as a tracer in biochemistry. When heavy hydrogen (deuterium) is substituted for ordinary hydrogen in water or in electrolytic solutions, the properties of the solutions are changed—the so-called "isotope effect." In addition, the acid-base properties of these solutions are manifested by the concentration or activity of deuterium ions (D^+) instead of by hydrogen ions (H^+) as in ordinary water. For this reason, the *p*H scale which is used to measure the acidity or basicity of aqueous solutions is not suitable for use with deuterium-containing solutions. Scientists at the NBS Institute for Materials Research are therefore establishing a new scale, the *p*D scale. This scale is at present based on two reference points which were determined [1,2] by R. Gary, R. A. Robinson, and R. G. Bates of the Institute's analytical chemistry laboratories.

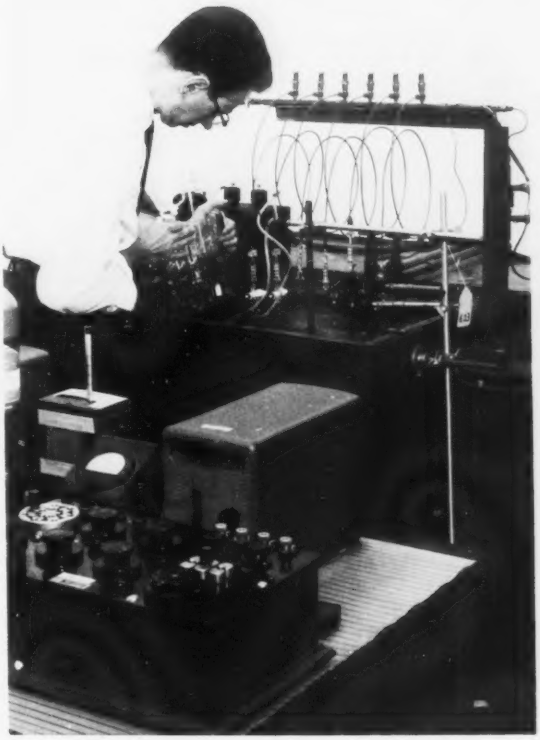
The *p*D scale measures the acidity or basicity of a deuterium-containing solution by comparing the deuterium ion activity of the solution with that of a reference solution whose deuterium ion activity has been precisely measured by an electromotive-force method in cells free from the uncertainties of a liquid junction. The calculated ion activity of the reference solution at a specified temperature and concentration gives a *p*D value which is used as a reference point on the *p*D scale. Before the *p*D values of reference buffer solutions could be determined, however, the standard emf of the cell chosen, namely,

$$\text{Pt}; D_2 \text{ (g, 1 atm)}, \text{DCl in } D_2O, \text{AgCl}; \text{Ag}$$

had to be accurately measured. This was done in the first [3] of a series of studies aimed at establishing the *p*D scale.

In subsequent studies the *p*D values for two different reference solutions were obtained. These solutions were equimolar mixtures of (1) potassium dideuterio phosphate (KD_2PO_4) and disodium deuterio phosphate (Na_2DPO_4) in heavy water; and (2) sodium acetate ($NaC_2H_3O_2$) and deuterio acetic acid ($DC_2H_3O_2$) in heavy water. The *p*D values for these buffers are the first two reference points on the *p*D scale.

Practical *p*D measurements can be made with the glass electrode, using the same equipment as that used for *p*H measurements because the surface potential of the glass electrode responds to changes in the *p*D when the electrode is immersed in heavy water. The *p*H assembly can therefore be adjusted to read correctly the known *p*D at the two reference points, and the *p*D values of "unknown" solutions that lie between these points can be interpolated. However, because the scale is not necessarily linear between reference points, the *p*D values at some distance from a reference point will tend to be less accurate than those that are close to a reference point. Therefore, to improve the accuracy of the scale over a wide range of *p*D values, additional reference points will be determined in the future.



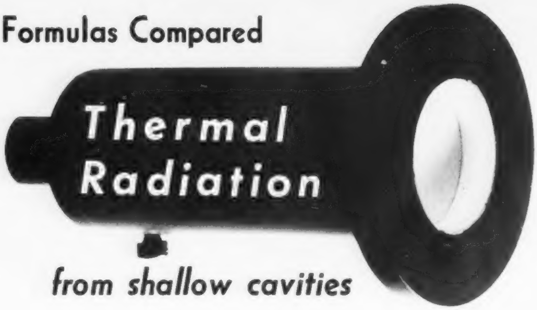
After the cell is assembled and filled with the heavy water buffer solution, Robert Gary positions it in a constant temperature water bath prior to emf measurements.

[1] *For further information, see* Second dissociation constant of deuterophosphoric acid in deuterium chloride from 5 to 50°—Standardization of a *p*D scale, *by R. Gary, R. A. Robinson, and R. G. Bates, J. Phys. Chem.* **68**, *3806 (1964).*

[2] Dissociation constant of acetic acid in deuterium oxide from 5 to 50°. Reference points for a *p*D scale, *R. Gary, R. G. Bates, and R. A. Robinson, J. Phys. Chem. (in press).*

[3] Thermodynamics of solutions of deuterium chloride in heavy water from 5 to 50°, *by R. Gary, R. G. Bates, and R. A. Robinson, J. Phys. Chem.* **68**, *1186–1190 (May 1964). Also,* pD scale being developed, *NBS Tech. News Bull.* **48**, *No. 11, p. 199 (Nov. 1964).*

Formulas Compared



Thermal Radiation

from shallow cavities

An investigation of the shallow-hole method for measuring thermal emittance of refractory materials at very high temperature is under way at the NBS Institute for Applied Technology. The accuracy of this method hinges upon the validity of theoretically derived expressions for determining flux emitted from isothermal cavities. The results of a study [1] by F. J. Kelly and D. G. Moore have shown that two of these expressions give values of emittance* that differ no more than 0.01 from the experimental values and are therefore valid.

Several general expressions predict the amount of flux emitted normal to the plane of the opening of a diffuse cylindrical cavity of any depth and any wall emittance. Two of the expressions, derived by A. Gouffé [2] and H. Buckley,[3] respectively, are relatively compact and easy to use. Another, derived by Sparrow, Albers, and Eckert,[4] requires the use of a digital computer. These expressions are not identical and yield different values for emitted flux. Therefore, to determine which expressions predict values of acceptable accuracy, the predicted values had to be compared with experimental results.

Kelly and Moore used a simple yet novel approach that has certain advantages over the direct method of measuring emittance at high temperatures. They eliminated the need to measure emittance directly by using the relation that, for opaque materials, emittance equals one minus reflectance. Thus, a spectrophotometer could be used to measure reflectance to 1 part in 1000, a precision not easily achieved with available thermal emittance equipment.

They designed a variable depth cylindrical cavity so that the cavity opening was the same size as the specimen opening in the spectrophotometer. Also, the cavity was lined with very diffuse colored paper which could be changed to provide a broad range of spectral reflectance. This eliminated the need to employ high temperatures. Thus all measurements could be performed at room temperature, insuring isothermal conditions in the cavity.

Staff member V. R. Weidner measured reflectance of the cavity from 0.40 to 0.75 μ at various depths. Each measured reflectance was subtracted from unity to obtain the emittance of the cavity. These values were compared to those predicted by the general expressions.

The comparison showed that Buckley's expression always predicted cavity absorptances higher than the experimentally determined values. The maximum deviation between them was 0.04. The expressions of Gouffé and of Sparrow et al. predicted values within 0.01 of the experimental ones under each test condition. These predicted values are within acceptable accuracy and can therefore be used in the shallow-hole method for measuring emittance. The Gouffé equation, however, is better suited for such work as it does not require the use of a computer.

**Emittance is the ratio of the flux per unit area radiated by a specimen to that radiated by a blackbody at the same temperature and under the same conditions.*

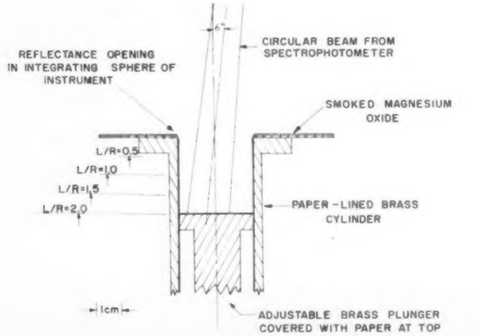
[1] A test of analytical expressions for the thermal emissivity of shallow cylindrical cavities, *F. J. Kelly and D. G. Moore, Applied Optics*, **4**, *31 (Jan. 1965)*.

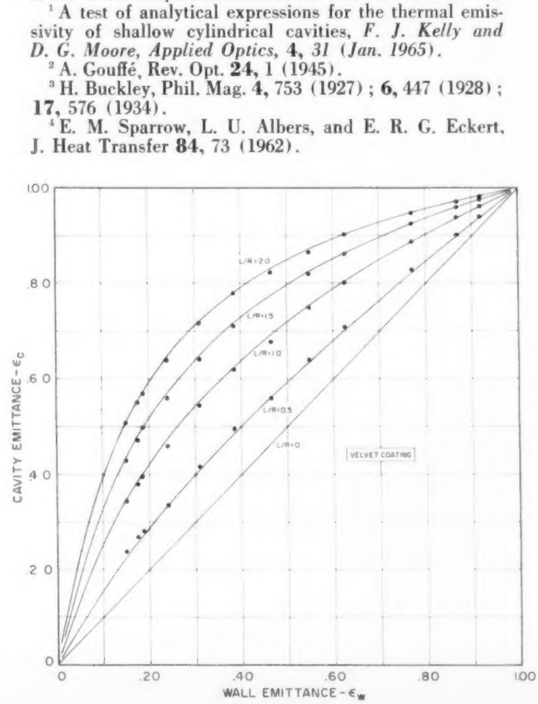
[2] A. Gouffé, Rev. Opt. **24**, 1 (1945).

[3] H. Buckley, Phil. Mag. **4**, 753 (1927); **6**, 447 (1928); **17**, 576 (1934).

[4] E. M. Sparrow, L. U. Albers, and E. R. G. Eckert, J. Heat Transfer **84**, 73 (1962).

Above: **Paper-lined cavity can be varied to give depth-to-radius (L/R) ratios from 0.0 to 2.0 in increments of 0.5.** ***Below:*** **Positions of plunger for various depth-to-radius (L/R) ratios, as well as the angle of the incident beam from the spectrophotometer are indicated on the sketch of the cavity.** ***Right:*** **Emittance values determined by reflectance technique were compared to values predicted by the Gouffé expression.**





Frequency Stability Calibration or Signal Sources

The frequency stability calibration of precision signal sources in the range from very low frequencies to 500 MHz has been announced as a regular service by the Radio Standards Laboratory (Boulder, Colo.). Previously, this service had been available only on a limited basis.

Equipment for frequency stability measurements, capable of accuracy of 1 part in 10^{10}, was developed by John H. Shoaf of the microwave calibration laboratory. Additional facilities will provide a similar calibration service to 1000 MHz, and it will be extended into the microwave region in the future. All measurements are made with reference to the U.S. Frequency Standard (cesium) which has a known accuracy of 1 part in 10^{11}.

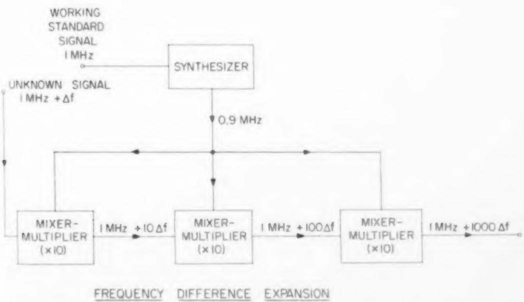
Signal sources submitted for calibration should provide a minimum power output of approximately 10 milliwatts (into a matched load) and have a frequency stability better than approximately 1 part in 10^{7}.

The calibration consists of measurements of both long-term (greater than one day) and short-term stability. The average frequency of the unknown signal source is determined for short intervals of time, and changes in these average-frequency values are observed. These changes are a measure of the frequency stability. Various techniques are employed in making the measurements, depending on the calibration required.

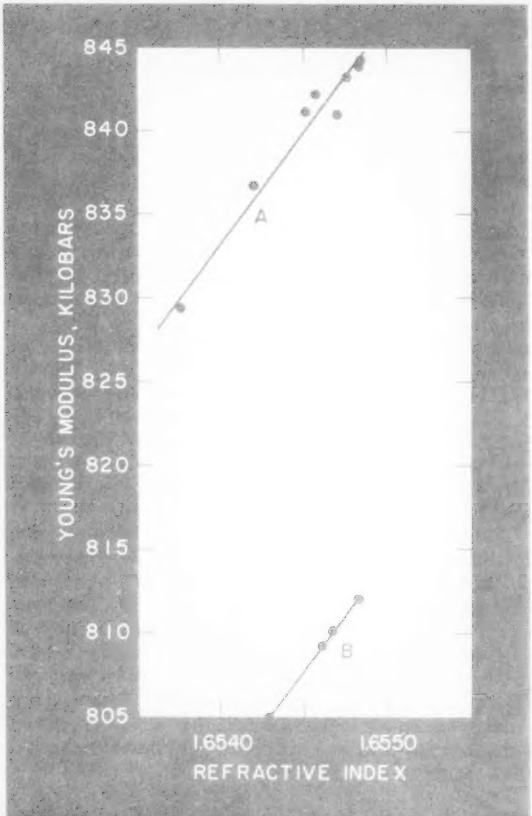
Direct counting of the number of cycles of the unknown frequency for an accurately known period of time is used. The unknown frequency usually is multiplied to a higher frequency value for greater accuracy. Electronic frequency counters, gated by a signal from an NBS working standard, are used for counting frequencies to 500 MHz.

Another approach compares the unknown frequency with an NBS working standard frequency by mixing the two frequencies in a nonlinear element and measuring the difference frequency obtained. The difference frequency is measured by the direct counting technique. When the difference frequency is very small, the accumulated phase of the difference frequency for a known period of time is measured. There are various techniques and equipment for doing this. An electronic frequency counter may be used, but in a manner essentially the reverse of the direct counting technique referred to above. The small difference frequency signal is applied to the portion of the counter that establishes the time-measurement function, and the working standard frequency signal is applied to the cycle-counting circuit. The result is a determination of the time required (in convenient units such as microseconds) for the phase accumulation of one or more complete cycles of the small difference frequency.

When the difference frequency is extremely small, the difference in phase between the unknown frequency and the working standard frequency may be recorded directly from phase-discriminating circuits, and the accumulated phase difference for a known period of time may be used to determine the difference frequency. Special circuits may be used to expand the difference frequency to a larger value before making a measurement. The difference frequency, Δf, can easily be expanded to a value of 1000 times the initial value.



Above: **Diagram of a technique for expanding the frequency difference between the unknown source and the working standard by a factor of 1000. The output signal frequency may be counted with a conventional 1-MHz counter.** ***Right:*** **John Shoaf examines a record from the frequency comparison equipment used to perform frequency stability calibrations for signal sources in the frequency range zero to 500 MHz. Shown are the phase comparison apparatus (left), electronic frequency counters and frequency difference expanders (center), and frequency multipliers (right).**



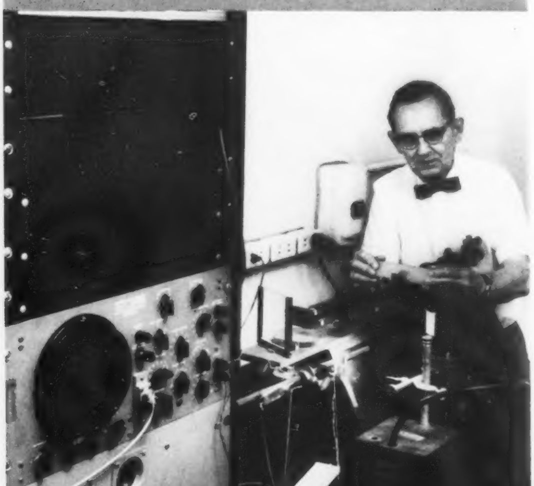
GLASS ME
REV

Varia of

In work at the NBS Institute for Materials Research Edgar H. Hamilton found that the relation between refractive index and Young's modulus of glass is a sensitive indicator of the nucleation and separation of submicroscopic phases.[1] Studies of the effect of heat treatment on this relation should reveal when nucleation and phase separation occur, as a large irreversible change in the relation between these properties accompanies the separation of a nucleated phase. The appearance and thermal behavior of the nucleated glasses are compatible with the widely accepted theory that there are definite short-range structures in glass.

Normally, an approximately linear relation exists between the elastic modulus and the refractive index of a glass as these properties are altered by heat treatment. However, during an NBS study of the effects of heat treatment on the properties of glass, repeated heat treatments of some glasses caused a sudden appreciable decrease in Young's modulus which was not accompanied by a decrease of equivalent magnitude in refractive index. The data obtained show that the sudden change resulted from a series of heat treatments—a "nucleating" treatment and a higher temperature "reaction" treatment. It is believed that during the first heat treatment, an immiscible phase was nucleated which on subsequent heat treatment at a higher temperature developed as a uniformly dispersed phase in the glass. Only one glass showed visible evidence of a change. The discoloration of this glass, which contained titanium dioxide, indicated the presence of submicroscopic particles.

The abnormal change in the relation between refractive index and Young's modulus often was observed following a treatment at some temperature at which the glass had previously been treated one or more times. However, the treatment producing the change always had been preceded by at least one treatment at a lower temperature. Repeating the treatment that caused the change sometimes resulted in a further decrease in



Above: **Changes in the relation of refractive index to Young's modulus produced in the glass $10SiO_2 \cdot 35B_2O_3 \cdot 55ZnO$ by repeated heat treatments at selected temperatures are shown. Curve A, before "abnormal" change; curve B, after change.** ***Below:*** **E. H. Hamilton is placing a glass specimen in the Grauer refractometer prior to determining its refractive index. At left is the apparatus used to measure Young's modulus. The suspended specimen (center foreground) is driven by an audio oscillator until one of the resonance frequencies of vibration is reached, as indicated on the oscilloscope screen.**

…HANICAL PROPERTIES …ALED BY HEAT TREATMENT

…iation of Refractive Index with Young's Modulus is Sensitive Indicator

Young's modulus with respect to refractive index. It was not possible with any heat treatment within the transformation range of the glass to restore Young's modulus to the higher linear relation to the refractive index.

The glasses investigated in the Bureau study included three-component zinc borosilicate glasses and other more complicated glasses based on the system ZnO–B_2O_3–SiO_2. The glasses were heat treated at various temperatures within their transformation (annealing) ranges for periods of six hours to six days, and were then cooled at a constant rate of 1 to 5° C per hour. After each heat treatment the room temperature refractive index and elastic moduli of the specimen were determined. Refractive indices were measured with a Grauer refractometer; and elastic moduli, by a dynamic resonance method.[2]

The simplest theory of glass structure assumes that glass is a random network. In the case of silicate glasses, this network would be of silicate ions with the modifying sodium, calcium, and other ions randomly dispersed in holes within the network. While on a macroscopic scale such may appear to be the case, the preponderance of evidence indicates that glasses have definite short-range structure. The number, size, and composition of the structural units are determined by the glass composition, probably to some extent by the melting procedure, and by the heat treatment the glass receives during processing for its intended use.

The slower the glass is cooled from the fabricating or annealing temperature, the denser its structure will be. If the density is altered by heat treatment, it is to be expected that other properties that are usually density-dependent, such as refractive index and Young's modulus, will be altered in a similar manner. Consequently, one would expect that glasses of identical compositions but different thermal histories would display different values of refractive index and elastic moduli which would be related to each other by a monotonic function. Such a situation should exist as long as there is no phase separation in the glass, that is, separation of a liquid phase which is immiscible in the glass or the appearance of crystals.

Some glasses can nucleate at temperatures at which the glass is too rigid for growth to occur. Such nuclei—although extremely small—are large enough to persist and become growth centers when the glass is heated to some higher temperature, but are too small to alter the monotonic relation between the properties.

When the glass is heated to a higher temperature the nuclei may grow either as liquid globules or as crystals. If this second treating temperature is also in the transformation range of the glass, growth of the nuclei may be limited to submicroscopic size as in the glasses under discussion.

Because the composition of the dispersed or nucleated phase differs from that of the matrix, the density and thermal expansion will also differ. The difference in thermal expansion will introduce microstresses in the composite structure. These stresses and the accompanying distortions in the dispersed phase and in the matrix will alter the fundamental resonance frequency of vibration of the specimen and thereby its elastic modulus while having little or no effect on its refractive index.

Another and possibly greater influence on the relations among the physical properties of the "nucleated" specimens arises from the properties of the phases developed within the specimens. In many glass-forming systems, an approximately linear relation exists among the properties of the glasses. For borosilicate glasses,[3] however, large deviations from linearity have been observed in the relations among refractive index, dispersion, density, and coefficient of linear expansion when the ratio of silica to boric oxide was varied in homologous series of glasses. The simple step-by-step substitution of B_2O_3 for SiO_2 in a barium-borosilicate glass causes the relation between the refractive index and the density of the glass to become nonlinear. For each homologous series, the properties usually attain a maximum value at some composition which is not the same for each property. Consequently, any relation observed between two given properties of a borosilicate glass may or may not hold for the individual phases which separate from the glass as the result of nucleation. A wide difference in properties may therefore be observed between a homogeneous glass of a given composition and a heterogeneous medium of the same overall composition, for instance, a glass in which phase separation has occurred.

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[1] *For further details, see* Changes in the relation between refractive index and Young's modulus as the result of successive heat treatments, *by Edgar H. Hamilton, J. Am. Ceramic Soc.* **47**, *No. 4, 167–170 (1964).*

[2] A method for determining mechanical reference frequencies and for calculating elastic moduli from these frequencies, *by S. Spinner and W. E. Tefft, Proc. ASTM* **61**, *1221–1238 (1961).*

[3] Some properties of glasses in the system barium oxide-boric oxide-silica, *by Edgar H. Hamilton, G. W. Cleek, and O. H. Grauer, J. Am. Ceramic Soc.* **41**, *No. 6, 209–215 (1958).*

Electronic Calibration Center Operates at Lower Humidity

For over half a year, the Electronic Calibration Center at the NBS Boulder laboratories has been using, with satisfactory results, a normal [1] controlled environment of 40 percent relative humidity (± 2 percent) at a temperature of 23 °C ($\pm 2°$). Previously, the normal relative humidity was 50 percent.

Operation at the lower humidity was initiated last July because it promised to bring with it several advantages. It lessens the problems of condensation during the winter season, and reduces the feeling of contrast as one moves into the controlled environment of higher humidity from the usually drier outside air that is characteristic of Colorado. Another consideration is the fact that a relative humidity of 40 percent at 23 °C seems close to the optimum comfort condition for laboratory activity.

Plans for the new Radio Standards Laboratory building at Boulder call for operation at 40 percent relative humidity at 23 °C in those laboratory areas where the environment will be controlled within narrower limits.

As far back as 1944, steps were taken to control the environment of the Bureau's microwave frequency standard. This resulted in the choice of temperature control at 22 °C and humidity control at 50 percent for rooms housing the microwave standards and calibration facilities. When the facility that houses the Electronic Calibration Center at Boulder was constructed, the choice was made to operate the controlled environment at 50 percent relative humidity with the temperature at 23 °C.

The last mentioned choice had been recommended by the Bureau of Federal Supply in *The Federal Standard for Laboratory Atmospheric Testing*, dated December 15, 1948. In 1953, in its standard for the conditioning of electrical insulating materials for testing, the ASTM specified a temperature of 23 °C and a relative humidity of 50 percent as a Standard Laboratory Atmosphere. In the middle 1950's, the NBS Radio Standards Division recommended these environmental conditions to the Army, Navy, and Air Force for operation of their standards laboratories that were then being planned for construction in large numbers.

Present operating specifications for many standards laboratories, particularly those in the DOD agencies, call for some latitude in the range of relative humidity. The recently available report of the ISA F–6 Environmental Committee,[2] entitled *Recommended Environments for Standards Laboratories*, suggests the selection of operation at a relative humidity within the range of 35 to 55 percent. Laboratories can choose a relative humidity that best suits their own purposes and conditions, as well as their climatic environment. There seems to be less dependence upon relative humidity, within limits, for the usual laboratory type of electrical and physical measurements than is found in the testing of materials, particularly organic substances.

It is usually unwise to operate at a relative humidity above 55 percent because of the very rapid increase in the rate of corrosion of iron and steel above a critical value around 60 percent. Similarly, it is unwise to operate in an environment below 35 percent for several reasons, the most important being that the lower humidities are unrealistic from the standpoint of comparison with uncontrolled laboratory conditions, except those of arid or semi-arid regions.

[1] *The "normal" environment does not apply to saturated standard cells, resistance standards, and other standards that are calibrated in oil baths at specific temperatures that are usually above room temperature.*

[2] Published in somewhat abbreviated form in ISA Transactions **3**, Issue 4, October 1964.

New Information Center Established at Oak Ridge

An Atomic and Molecular Processes Information Center has been established at the Atomic Energy Commission's Oak Ridge (Tennessee) National Laboratory to compile and evaluate data on atomic and molecular physics.

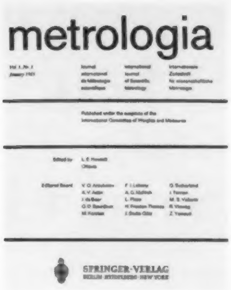
Sponsored jointly by the National Bureau of Standards and the Atomic Energy Commission, the Center will be part of the National Standard Reference Data program and will serve as a focal point for the collection, storage, evaluation, and dissemination of information generated throughout the world. All information will be evaluated by scientists working in the field of atomic and molecular collisions.

Initially the Center's activities will be limited to atomic and molecular cross-section data and other particle collision process information in these specific areas: (1) The interaction of heavy particles, (2) particle penetration through matter, and (3) excitation, dissociation, ionization, and detachment by external electric and magnetic fields.

The new information center will contribute to the systematic data-compiling activities in the United States. The National Standard Reference Data program administered by the Bureau was established in 1963 to coordinate data-compiling activities under Government sponsorship.

The Center will begin full operation about July 1, when inquiries may be addressed to C. F. Barnett, Director, Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn.

The Laboratory, one of the nation's principal atomic energy research and development facilities, is operated by Union Carbide Corporation for the AEC.



metrologia

International Journal of Scientific Metrology

Volume 1, Number 1, of *Metrologia*, an international quarterly journal of scientific metrology, published under the auspices of the International Committee of Weights and Measures, came from the presses in March of this year.[1] The new journal gives effect to a decision taken in October 1963 [2] by the International Committee, on which the United States is represented by NBS Director A. V. Astin.

L. E. Howlett of the National Research Council, Canada, and present Chairman of the International Committee, is Editor, and Dr. Howlett is seconded by an Editorial Board of fifteen members including two U.S. members, Dr. Astin and A. G. McNish, Chief of the NBS Metrology Division. The International Committee, composed of representatives of various national standards laboratories, supervises the scientific program of the International Bureau of Weights and Measures at Sèvres, France.

The four articles of the first issue illustrate well some of the editorial plans for the journal.

In the opening article, "A Determination of the Ampere," P. Vigoureux of the National Physical Laboratory (Teddington, England) reports on a determination of the unit of electrical current in terms of the units of mass, length, and time, using the NPL Ayrton-Jones current balance. Apparatus, procedure, sources of error, and accuracy of the final figure are discussed; and the result is combined with previous measurements at the same laboratory to obtain a value for the gyromagnetic ratio of the proton in water, uncorrected for diamagnetism.

Professor Norman Ramsey of Harvard writes on "The Atomic Hydrogen Maser." This is a detailed summary of experiments with a technique which would permit construction of time-interval and frequency standards that promise to be independently reproducible with greater precision even than the present cesium atomic standards. The latter are now used, for example, to control the standard time and frequency broadcasts of the NBS radio stations.

The last two papers emphasize the journal's connection with the central international organizations and programs in scientific metrology. In the first half of his contribution, Dr. Jean Terrien, Director of the International Bureau of Weights and Measures, presents a historical survey covering nearly 100 years, bringing the reader up to date on the organization and functions of the Bureau and its relations to the International Committee of Weights and Measures with its seven consultative committees and to the General Conferences of Weights and Measures. The other half is an account of the most recent technical activities of the Bureau in conjunction with the cooperating national laboratories and the consultative committees in the areas of length, mass, temperature, electrical, photometric, and ionizing radiation measurements; and it closes with a statement on the current status of the International System (SI) of Units.

In the last article, Dr. H. Moreau, Assistant to the Director of the International Bureau, reports in succinct and systematic fashion the principal actions and recommendations of the Twelfth General Conference of Weights and Measures which met in Paris in October 1964.

These articles illustrate only a part, though an important part, of what is planned for the journal, as given by the statement which appears on the inside front cover of the publication:

> "Metrologia invites for publication articles that report the results of original researches directed towards the significant improvement of fundamental measurements in any field of physics. Those submissions that concern an improvement to the standards of the six units of the International System of Units (meter, kilogramme, second, ampere, degree, candela) or proposals to replace them with better ones will be particularly welcome. In addition, original articles are invited that contribute to the accuracy of derived units having a fundamental importance in physics—such as the velocity of light, the gyromagnetic ratio of the proton, the acceleration due to gravity, etc.—or that contribute to the solution of particularly difficult measurement problems such as now exist in the fields of ionizing radiations and high frequency electrical phenomena. Although in general Metrologia will prefer to publish articles of the above character that have fundamental importance in the development of measurement, others that report new methods or improvements to existing methods that contribute in a significant way to the making of secondary measurement will be accepted. The journal will also publish review articles covering various fields of measurement. Letters to the Editor are warmly invited and it is hoped that this section of Metrologia will become a useful forum for discussion and exchange of views in the broadest possible way on primary physical measurement and its improvements and thereby draw attention quickly to the development of new trends of thought and experiment in this area of physical research. Reports will be given regularly of the activities, decisions, and recommendations of the International Conference of Weights and Measures, the International Committee of Weights and Measures and its advisory committees, and of the International Bureau of Weights and Measures at Sèvres."

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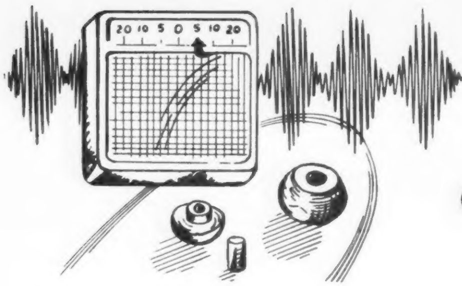
[1] Subscriptions are $8.50 a year and may be obtained from Springer-Verlag New York, Inc., 175 Fifth Avenue, New York, N.Y., 10010. The address for editorial communications is: The Editor, *Metrologia*, Division of Applied Physics, National Research Council, Ottawa 2, Ontario, Canada. Articles are expected to be in English, French, German, or Spanish, with summaries in English of non-English articles. As it happens, all the main articles in the first issue are in English.

[2] NBS Tech. News Bull. **48**, 10 (Jan. 1964).



Standards and Calibration

Waveguide Calibration Changes

The Radio Standards Laboratory (Boulder, Colo.) has announced an extension of the attenuation calibration service to include WR 28 size waveguide (26.5–40.0 GHz). The service includes attenuation difference measurements on variable attenuators and insertion loss measurements on fixed attenuators. This provides an attenuation calibration service over eight waveguide sizes, covering a frequency range from 2.60 to 40.0 GHz. Development work is in progess to extend the service to several waveguide sizes above and below the present limits of 2.6 and 40.0 GHz.

The Radio Standards Laboratory has discontinued the attenuation measurement of three-port and four-port waveguide directional couplers, accepting only two-port waveguide attenuators for calibration. For some years the Bureau has provided a calibration service for three-port and four-port waveguide directional couplers for use as highly stable, fixed-value attenuation standards. With the "in-line" type of precision, fixed-waveguide attenuator becoming commercially available, the superior features of this type of attenuator make the use of the older directional coupler obsolete as a fixed attenuation standard.

Improved Attenuation Measurements at Microwave Frequencies

An improvement in accuracy for attenuation difference measurements on variable attenuators from 0.1 dB/10 dB to 0.05 dB/10 dB (0.5 percent of the attenuation in decibels) has been available for some time in WR 90 waveguide (8.2–12.4 GHz). More recently this increased accuracy has become available in four additional waveguide sizes:

WR 284 (2.6–3.95 GHz)
WR 187 (3.95–5.85 GHz)
WR 137 (5.85–8.2 GHz)
WR 62 (12.4–18.0 GHz)

An accuracy of 0.1 dB/10 dB (1 percent of the attenuation in decibels) is reported for insertion loss measurements of fixed attenuators.

This improvement in accuracy of the attenuation measurement leads to a corresponding improvement in the impedance match at the attenuator insertion points. Formerly the mismatch produced a VSWR of 1.05 or less; whereas it is possible now to hold the mismatch to a VSWR below 1.02.

Measurement of Waveguide Reflectors Extended to Additional Waveguide Size

Measurement of the reflection coefficient magnitude of waveguide reflectors (mismatches) in WR 62 waveguide (12.4–18.0 GHz) has been announced by the Radio Standards Laboratory as a calibration service. Previously the service was available in only one waveguide size, that of WR 90 (8.2–12.4 GHz).

Although measurement of the reflection coefficient magnitude can be made at any frequency over the range of 12.4 to 18.0 GHz, it should be emphasized that measurements are made at selected frequencies of 13.5, 15.0, and 17.0 GHz. This is done primarily for the economy and convenience of those requesting calibrations. Measurements can be made over a magnitude range of 0.025 to 1.0 with an uncertainty of ±1 percent. It is very essential that the flange be machined flat and smooth and be without protrusions or indentations.

Calibration of RF Calorimeters Extended to 500 MHz

The Radio Standards Laboratory announces that the calibration of coaxial-type rf calorimeters is now extended in frequency range to 500 MHz. Formerly the upper frequency limit was 400 MHz. Calibrations at cw power levels between 0.001 to 100 watts are made at the selected frequencies of 100, 200, 300, 400, and 500 MHz. Below 100 MHz measurements can be made at power levels extending up to 200 watts. Uncertainties in the measurements are expressed in the range of one to two percent, depending upon the stability and SWR of the calorimeter being calibrated.

X-Band Bolometric and Calorimetric Standards

With the availability of suitable traveling-wave tube amplifiers, it is now possible to obtain microwave energy at considerably higher power, and with good stability and low noise. This source of cw microwave power is being utilized by the Radio Standards Laboratory to perform calibrations up to a power level of one watt on bolometric and calorimetric devices in the frequency range of 8.2 to 12.4 GHz (X-Band). Formerly the power level was limited to 100 milliwatts. Uncertainty in the measurements is expected to be no greater than one percent.

Waveguide Bolometer-Coupler Units

The calibration of waveguide bolometer-coupler units [1] for use as power measurement devices at

microwave frequencies requires a determination of the equivalent reflection coefficient looking into the output port of the coupler. Determination of the equivalent reflection coefficient by the Radio Standards Laboratory at Boulder is made preferably with the bolometer unit detached from the coupler, though the determination can be made with the bolometer unit attached. It will be future practice, unless the Laboratory is specifically instructed otherwise, to separate the bolometer-coupler units in order to initially determine the equivalent reflection coefficient. Upon repeating a power calibration, if the measurement shows no marked change from the previous calibration, the determination of equivalent reflection coefficient will not be repeated. However, if there is a change in the power calibration, Γ_g will be redetermined with the bolometer-coupler unit intact in order to better preserve the calibration history.

[1] *See* Extension of waveguide power calibration service, *NBS Tech. News Bull.* **47,** *141 (Aug. 1963).*

***For additional calibration information, see* Frequency Stability Calibration of Signal Noises on page 89.**

Canada and U.S. Compare Inductive Voltage Divider Calibrations

An international comparison of inductive voltage divider calibrations between the National Research Council of Canada and the NBS Institute for Basic Standards was recently completed.[1] This insures a uniform basis for voltage-ratio measurements in the two countries.

Thanks to the inductive voltage divider, voltage-ratio determinations are among the most accurate in the field of electrical measurements, and their use is steadily becoming more common in industry as well as pure science. To mention but one type of application, accurate voltage dividers are critical items in the development of control and guidance networks of space vehicles and other advanced systems.

The intercomparison was based on calibration results independently obtained on the same test divider by laboratories in both countries. To make it easier to detect changes that might result from transportation of the device, and to separate such changes from interlaboratory differences, the following sequence was adopted: (1) initial calibration at the NBS Washington laboratories; (2) shipment to NBS Boulder laboratories for a separate calibration; (3) return to Washington for a repeat calibration; (4) shipment to Ottawa for the Canadian calibration; (5) return to Washington for a second repeat calibration.

At the National Research Council, Ottawa, the test divider was calibrated by direct comparison with the three-terminal capacitive divider.[2] All measurements were made using a capacitance bridge with a ratio-arm transformer. The ratio of this transformer, loaded by the test divider and measuring capacitors, was measured during the sequence of balances. An auto-calibration technique was used, based on the assumption that the corrections to the test divider were zero at the terminals, from which assumption the corrections of the bridge transformer were also determined. The accuracy and consistency of the auto-calibration technique were verified by independent information on the characteristics of the bridge transformer.

At the laboratories in Boulder, the test divider was calibrated by direct comparison with a "standard" divider. In the "standard" divider method the voltage-ratio and phase-angle errors of the "standard" were determined by comparison with a series of specially constructed single-decade inductive voltage dividers with calculable relative corrections resulting from the interaction between the distributed shunt and leakage impedances in the windings.[3]

In the capacitive-divider method, used in the Washington laboratories,[4] the relative values of the three-terminal capacitors were obtained by intercomparison in a bridge having transformer-type ratio arms. Incorporated in this bridge are a few special components: (1) Specially constructed decades of three-terminal capacitors, each decade buried in a mounting block to achieve a relatively strain-free and isothermal mounting that gives good attenuation of ambient temperature and pressure changes; (2) the ratio-arm transformer, with the voltage ratio and phase angle of its secondary windings measured to an accuracy of better than one part in 10 million; and (3) a phase-sensitive detector, with a square-wave signal impressed on the horizontal deflection system of the CRT, capable of indicating an unbalance signal to almost an order of magnitude better than any other available detector.

This is the first international comparison of inductive voltage divider calibrations in which these national laboratories have participated. The close agreement in the results obtained by three independent methods indicated that in each of the laboratories concerned the voltage-ratio and phase-angle measurements are accurate to within 1 part in 10 million of input and $1/(\text{setting of dials})^{1/2}$ microradians at 400 and 1000 Hz.

[1] An international comparison of inductive voltage divider calibrations at 400 and 1000 Hz, *by W. C. Sze, A. F. Dunn, and T. L. Zapf. IEEE Paper No. 345, presented at the 1965 IEEE International Convention, New York, Mar. 22–25, 1965.*

[2] Determination of an absolute scale of capacitance, *by A. F. Dunn, Can. J. Phys.* **42,** *53, 1964.*

[3] Inductive voltage dividers with calculable relative corrections, *by T. L. Zapf, C. H. Chinburg, and H. K. Wolf. IEEE Trans. on Instrumentation and Measurement, Vol.* **IM–12,** *p. 80, September 1963.*

[4] *An outline of the calibration procedures used at the Washington NBS laboratories, and further references to the literature, are given in NBS Tech. News Bull.* **49,** *No. 1 (Jan. 1965).*

PUBLICATION and CONFERENCE *Briefs*

NOTE: Publications mentioned in this column, unless otherwise stated, are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, and through local U.S. Department of Commerce field offices. NBS Mono. 80, $2.75; NBS J. Res., Sec. B, $0.75.

New Publication: Ionospheric Radio Propagation, by Kenneth Davies

Information obtained from space vehicles and such special geophysical efforts as the International Geophysical Year and the International Year of the Quiet Sun, have greatly increased our knowledge of ionospheric radio propagation in recent years. The scope of this important new NBS publication, Monograph 80, has therefore been broadened to include aspects of ionospheric radio propagation not treated in an earlier version (Circular 462) issued in 1948. Such topics as electron-layer production, the geomagnetic field, magneto-ionic theory, and oblique propagation have been expanded with respect to the earlier treatment. While the book is devoted largely to the propagation of high-frequency radio waves, two chapters have been included to give a better perspective of the relationship of the high-frequency band to the lower frequency (LF and VLF) bands and upper (VHF) frequency band, insofar as propagation characteristics are concerned.

This book has been prepared in a form suitable for teaching purposes and should be a valuable reference source for research workers and communications engineers who already have some background knowledge of ionospheric radio propagation.

NBS Journal of Research Features Matroids

Current research activity on matroids, a relatively new branch of mathematics, is the subject of a special double issue of the NBS *Journal of Research, Section B (Mathematics and Mathematical Physics)*, now available. Matroids are expected to be of great value in the theory of linear programming and in electrical network design.

Six papers on matroids are included in the combined January–June issue of the *Journal of Research, Section B (Mathematics and Mathematical Physics)*, (Vol. 69B, No. 1 and 2). *Section B* is normally published as a quarterly. The papers were given during the first Seminar on Matroids, held August 31–September 11, 1964 at NBS. The Seminar was attended by 30 mathematicians from the United States and Canada, and provided a means of information exchange among those who have done "groundwork" on matroid theory.

Matroids (like groups, for example) are mathematical systems obeying certain axioms. A matroid consists of a set of elements and certain distinguished subsets which are called independent. The prime example is that in which the elements are the columns of a matrix and the distinguished subsets are taken as the linearly independent subsets of these columns.[1]

The pioneer in the theoretical use of matroids is W. T. Tutte, Professor of Mathematics at the University of Waterloo in Ontario, Canada, whose "Lectures on Matroids" are included in the special issue of the NBS Journal. Professor Tutte characterizes in terms of "regular matroids" those matrices in which every minor determinant has the value 0,1, or -1. Such matrices are of great value in the theory of linear programming. He also characterizes in terms of "graphic matroids" those matrices which arise from electrical networks via Kirchhoff's laws. These matrices have applications in electrical network design.[2]

Not all matroids arise from matrices, so that matroid theory does truly generalize an aspect of linear algebra. At present, however, its importance for applications appears to lie in its ability to treat new problems and solutions in the theories of matrices and networks.

The Applied Mathematics Division of the NBS Institute for Basic Standards seeks to stimulate interest in new fields of mathematics which will be useful in meeting the future scientific needs of industry and government.

Optical Propagation Conference

A Conference on Atmospheric Limitations to Optical Propagation attracted over 250 scientists interested in optical research to the Boulder (Colo.) Laboratories of the Bureau March 18 and 19. The Conference was sponsored jointly by the NBS Central Radio Propagation Laboratory (CRPL) and the National Center for Atmospheric Research (NCAR). Organized to bring together experts from fields relating to optical propagation, the Conference was so enthusiastically received that it was attended by four times as many scientists as originally expected. They came from the laboratories of government, industry, and universities. Canada, Italy, India, France, and England were represented.

CRPL is conducting a growing program of research in optical propagation, and hence joined in sponsoring the Conference as part of its mission to obtain and disseminate information. CRPL Director C. Gordon Little served as Conference Chairman. Colorado Governor John A. Love was guest speaker at the Conference banquet.

Many of the papers delivered at the Conference reported experiments on light from lasers. Electromagnetic energy in this part of the spectrum is now undergoing extensive study as a telecommunications

medium and the transmission limitations imposed by the atmosphere are of vital interest to communications scientists and engineers. No proceedings of the Conference will be published, but abstracts of the papers presented will appear at an early date in *Radio Science*. [*Radio Science*, formerly *Radio Propagation*, is published by the Bureau, in cooperation with the U.S. National Committee of the International Scientific Radio Union (USNC–URSI)]. It is published monthly as *Section D of the Journal of Research of the National Bureau of Standards* ($1.00 a copy; annual subscription: $9.00 in the United States, $11.50 foreign).

Particle Accelerator Conference

Specialists in the rapidly advancing field of particle acceleration met in Washington, D.C., on March 10–12 to discuss the physics and engineering aspects of a broad range of modern accelerator design and operating problems. The first meeting of its kind to be completely open to the public, the Particle Accelerator Conference drew an attendance of 800 from government, industry, and the universities. Representation was well distributed between physicists and engineers, and between specialists in high- and low-energy accelerators.

The meeting was sponsored by the Nuclear Science Group of the Institute of Electrical and Electronics Engineers, the American Physical Society, the Atomic Energy Commission, and the Institute for Basic Standards of the National Bureau of Standards. Chairman of the Conference was R. S. Livingston of the Oak Ridge National Laboratory.

The Conference performed a much-needed service in bringing together both the builders of accelerators and the present and potential users. In many cases applications of the newer developments in particle acceleration are being delayed because potential users are not aware of the advanced state of the technology.

Over 90 papers were given at the 10 Conference sessions while 132 others were accepted but not read. The content of these papers clearly showed the sophistication which the field of particle acceleration has attained in recent years.

The Conference began with opening remarks by Chairman Livingston and a welcoming address by NBS Director A. V. Astin. The rest of the first day was devoted to sessions on accelerator component controls and automation systems; radio-frequency sources and accelerating structures; and d-c accelerators and auxiliaries.

Two sessions were devoted to beam systems and beam dynamics, and a session each to magnets and power supplies and to ion source and high-voltage technology. Because of the necessity for extreme caution as new machines produce beams of higher and higher energies and higher and higher intensities, a session was held at which safety systems, shielding, radiation effects, and radiation protection were discussed. Another session, which aroused considerable interest, dealt in general terms with the performance of existing accelerators, accelerator designs, facilities and costs, but perhaps the most spirited was the session devoted to future accelerators.

On the morning following the Conference, about 50 of the participants were given a tour of the nearly completed linear accelerator facility of the National Bureau of Standards at its Gaithersburg site. This accelerator, when completed, will produce one of the world's most intense high-energy electron beams.

The complete proceedings of the Conference are being published by the Nuclear Science Group of the IEEE and will be available to the public in the June 1965 issue of the IEEE Transactions on Nuclear Science.

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[1] Minimum partition of a matroid into independent sets, *by Jack Edmonds, J. Res. NBS* **69B** *(Math. and Math. Phys.) Nos. 1 and 2, 67–72 (1965).*

[2] Lectures on matroids, *by W. T. Tutte, J. Res. NBS* **69B** *(Math and Math. Phys.) Nos. 1 and 2, 1–47 (1965).*

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. **49**, No. 5, May 1965. 15 cents. Annual subscription: $1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

CRPL Ionospheric Predictions for August 1965. Three months in advance. Number 29, issued May 1965. 15 cents. Annual subscription: $2.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75. Single copy, 70 cents.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

Section D. Radio Science. Issued monthly. Annual subscription: Domestic, $9; foreign, $11.50. Single copy, $1.00.

Current Issues of the Journal of Research

J. Res. NBS **69A** *(Phys. and Chem.), No. 3 (May–June 1965).*

Electronic structure and magnetic properties of the neptunyl ion. J. C. Eisenstein and M. H. L. Pryce.

Heats of transformations in bismuth oxide by differential thermal analysis. E. M. Levin and C. L. McDaniel.

Phase relations between iridium and the sesquioxides in air. S. J. Schneider, J. L. Waring, and R. E. Tressler.

Phase equilibrium relationships in the system Gd_2O_3—TiO_2. J. L. Waring and S. J. Schneider.

Acid-base behavior in 50-percent aqueous methanol: thermodynamics of the dissociation of protonated tris (hydroxymethyl) aminomethane and nature of the solvent effect. M. Woodhead, M. Paabo, R. A. Robinson and R. G. Bates.

Observations of dislocations and surface features in corundum crystals by electron transmission microscopy. D. J. Barber and N. J. Tighe.

Low-frequency dielectric properties of liquid boric oxide. K. H. Stern.

Mass spectrometric study of the effects of nitric oxide and other additives on "purified" active nitrogen. J. T. Herron.

Synthesis and ring structure of 7-acetamido-7-deoxy-L-*galacto*-heptulose. E. J. McDonald.

Radio Sci. J. Res. NBS/URSI **69D**, *No. 6 (June 1965).*

"Waves in Plasma" Papers

Cyclotron harmonic waves in warm plasmas. F. W. Crawford.

Propagation of waves across a magnetoplasma-vacuum boundary. R. L. Gallawa.

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Phase velocities and attenuation distances in the ionosphere. D. R. Croley, Jr., and B. S. Tanenbaum.

Ionospheric effects of electrostatic fields generated in the outer magnetosphere. G. C. Reid.

An experimental study of plasma sheath effects on antennas. G. Tyras, P. C. Bargeliotes, J. M. Hamm, and R. R. Schell.

An approach to improve re-entry communications by suitable orientations of antenna and static magnetic field. S. N. Samaddar.

Concerning the mechanism of reflection of electromagnetic waves from an inhomogeneous lossy plasma. J. R. Wait.

Selection of Papers Presented at 1964 World Conference on Radio Meteorology, Boulder, Colo., Sept. 14–18, 1964

Angels in focus. D. Atlas.

An investigation of clear air stratification with radar and elevated instruments. D. R. Hay and K. Naito.

On inferring the refractive-index structure of the troposphere from electromagnetic scattering experiments. P. L. Smith, Jr.

The biexponential nature of tropospheric gaseous absorption of radio waves. E. J. Dutton and B. R. Bean.

Complete scattering parameters of polydispersed hydrometeor in the $\lambda 0.1$ to $\lambda 10$ cm range. D. Deirmendjian.

Other NBS Publications

Effects of thermal shrinkage on build-up roofing, W. C. Cullen, NBS Mono. 89 (Mar. 4, 1965), 10 cents.

Automatic indexing: A state-of-the-art report, M. E. Stevens, NBS Mono. 91 (Mar. 30, 1965), $1.50.

The examination of weighing equipment, M. W. Jensen and R. W. Smith, NBS Handb. 94 (Mar. 1, 1965), $3.00. (Supersedes H37)

Standard frequency and time services of the National Bureau of Standards, NBS Misc. Publ. 236 (Jan. 15, 1965), 15 cents. (Supersedes editions of Dec. 1, 1960 and July 1, 1961).

Standard Reference Materials: Accuracy of solution x-ray spectrometric analysis of copper-base alloys, R. Alvarez and R. Flitsch, NBS Misc. Publ. 260-5 (Mar. 15, 1965), 25 cents.

Thermal properties of aqueous uni-univalent electrolytes, V. B. Parker, NSRDS-NBS2 (Apr. 1, 1965), 45 cents.

Builders' template hinges, CS9-65 (Jan. 15, 1965), 10 cents. (Supersedes CS9-33).

Aluminum alloy chain link fencing, CS269-65 (Mar. 1, 1965), 10 cents.

Optical scintillation; a survey of the literature, J. R. Meyer-Arendt and C. B. Emmanuel, NBS Tech. Note 225 (Apr. 5, 1965), 70 cents.

Microwave reflection techniques for dense plasma diagnostics, S. Takeda and T. Tsukishima, NBS Tech. Note 256 (Mar. 10, 1965), 25 cents.

Practical aspects of the use of AC–DC transfer instruments, E. S. Williams, NBS Tech. Note 257 (Mar. 9, 1965), 15 cents.

Bibliography of fading on microwave line of sight tropospheric propagation paths and associated subjects, H. T. Dougherty, NBS Tech. Note 302 (Aug. 31, 1964), 60 cents.

Bibliography on tropospheric propagation of radio waves, W. Nupen, NBS Tech. Note 304 (Apr. 1, 1965), $2.00.

Atlas of Fourier coefficients of diurnal variation of foF_2 Part II. Distribution of amplitude and phase, W. B. Jones and R. M. Gallet, NBS Tech. Note 305 (Feb. 14, 1965), 60 cents.

Summary of current research on archival microfilm, C. S. McCamy and C. I. Pope, NBS Tech. Note 261 (Apr. 16, 1965), 25 cents.

Publications in Other Journals

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Chemistry:

A calorimetric determination of the enthalpy of graphite from 1200 to 2600 °K, E. D. West and S. Ishihara (Proc. 3d Symp. Thermal Physical Properties, Purdue Univ., Lafayette, Ind., Mar. 22-26, 1965), Book, Advances in Thermophysical Properties at Extreme Temperatures and Pressures, p. 146–151 (American Society of Mechanical Engineers, New York, N.Y., 1965).

Blood:bone equilibrium in calcium homoeostasis, J. MacGregor and W. E. Brown, Nature **205**, No. 4969, 359–361 (Jan. 23, 1965).

Engineering and instrumentation:

A high-speed (milliseconds) method for the simultaneous measurement of enthalpy, specific heat, and resistivity of electrical conductors at high temperatures, A. Cezairliyan (Proc. 3d Symp. Thermophysical Properties, 1965), Book, Advances in Thermophysical Properties at Extreme Temperatures and Pressures, pp. 253–262 (American Society of Mechanical Engineers, New York, N.Y., 1965).

A magnetic amplifier for use with diode logic, E. W. Hogue, IEEE Trans. Commun. Electron. **83,** No. 75, 803–808 (Nov. 1964).

Mathematics:

A theorem on the automorphs of a skew-symmetric matrix, M. Newman, Mich. Math. J. **12,** 61–63 (1965).

On the location of the zeros of some infrapolynomials with prescribed coefficients, J. L. Walsh and O. Shisha, Pacific J. Math. **14,** No. 3, 1103–1109 (1964).

On the structure of infrapolynomials with prescribed coefficients, O. Shisha, Pacific J. Math **14,** No. 3, 1039–1051 (1964).

Metrology:

Continuous-absorption hygrometry with a pneumatic bridge utilizing critical flow, W. A. Wildhack, T. A. Perls, C. W. Kissinger, and J. W. Hayes (Proc. 1963 Intern. Symp. Humidity and Moisture, Washington, D.C.), Book, Humidity and Moisture. Measurement and Control in Science and Industry. Vol. 1, Principles and Methods of Measuring Humidity in Gases, Sec. VI, Paper 53, pp. 552–570 (Reinhold Publ. Corp., New York, N.Y., 1965).

Physics:

Absolute measurement of W for polonium-210 alpha particles in nitrogen, argon, and argon-methane mixture, Z. Bay and F. D. McLernon, Radiation Res. **24,** No. 1, 1–8 (Jan. 1965).

Atomic lifetimes in neon I, J. Z. Klose, Astrophys. J. **141,** No. 2, 814–818 (Feb. 15, 1965).

Radio science:

Cosmic noise absorption events at geomagnetically conjugate stations, C. G. Little, E. R. Schiffmacher, H. J. A. Chivers, and K. W. Sullivan, J. Geophys. Res. **70,** No. 3, 639–648 (Feb. 1, 1965).

Fluctuations in a laser beam over 9- and 90-mile paths, W. R. Hinchman and A. L. Buck, Proc. IEEE **52,** No. 3, 305–306 (Mar. 1964).

Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

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